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## RESEARCH ARTICLE

# Dog health and demographic surveillance survey in Western Kenya: Demography and management practices relevant for rabies transmission and control [version 1; peer review: 4 approved with reservations]

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## Abstract

**Background:** Domestic dogs transmit 99% of the estimated 59,000 human rabies deaths occurring globally annually. To achieve the global target of zero human deaths from rabies by 2030, effective mass dog vaccination campaigns that break rabies transmission cycles in dog populations are required. This study describes the design of a dog health and demographic surveillance study established within a human health and demographic surveillance study in Western Kenya. Using baseline data from the dog cohort study, we quantify demographic parameters and describe management practices relevant for rabies transmission.

**Methods:** All dogs in 1213 households participating in a linked human and animal health syndromic surveillance study were recruited. Data on household demographics, dog ownership, dog age and sex ratios, reproductive indices, rabies vaccination, management practices, dog movement and health status were collected at least monthly.

**Results:** 460 of 1213 (38%) of the study households owned dogs (mean 2 dogs/household), and 526 (70%) of those without dogs had owned dogs previously. 802 dogs were recruited into the study, more than half (52%) of those with known ages were  $\leq 1$  year old. The dog:human ratio in the study population was 1:7, the dog density 54 dogs/km<sup>2</sup>, and the female: male dog sex ratio was 1:1.3. Rabies vaccination was low (5% coverage), and only 48 (12%) male dogs and 13 (5%) female dogs were castrated and spayed, respectively. Dogs were predominantly local breed (99%), mainly kept for security purposes, almost always (97%) left to scavenge for leftovers and 61% roamed freely.

**Conclusion:** Low vaccination coverage, unrestricted dog movement, and high dog population turnover with a large proportion of dogs below one-year-old support endemic rabies circulation in this population. These

## Open Peer Review

Reviewer Status

	Invited Reviewers			
	1	2	3	4
version 1				
published	report	report	report	report
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Any reports and responses or comments on the article can be found at the end of the article.

gaps present opportunities for the design of effective dog rabies control plans to break rabies transmission cycles in this part of Kenya.

### Keywords

Dog, demographics, ecology, Kenya, rabies

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## Introduction

Rabies kills an estimated 59,000 people annually, mostly in Asia and Africa and among rural populations<sup>1</sup>. In Africa, the domestic dog is the reservoir host for the rabies virus and the main source of human rabies cases. The control and elimination of rabies in domestic dogs is critical for eliminating human deaths from rabies<sup>2-4</sup>. The low basic reproductive number for rabies in dogs supports the feasibility of controlling rabies through vaccination<sup>5</sup>. Mass dog vaccination, reaching 70% of the dog population, is recommended as a cost-effective way to interrupt the transmission cycle and thereby eliminate human deaths due to dog-mediated rabies<sup>5,6</sup>. However, high dog population turnover leads to rapid declines in herd immunity between vaccination intervals as new susceptible dogs are introduced to the population and immunized dogs leave the population through death<sup>5,7</sup>. Knowledge of dog population demographic rates and local ecology is critical in designing rabies elimination programmes, including the frequency of mass dog vaccination campaigns.

In 2014, Kenya launched a National Rabies Elimination Strategic Plan for the elimination of dog-mediated human rabies by the year 2030<sup>8</sup>. This goal is in line with the global target for zero deaths from human rabies endorsed by the World Health Organization and partners<sup>9</sup>. The Kenya strategy focuses on mass dog vaccinations, timely provision of post-exposure prophylaxis

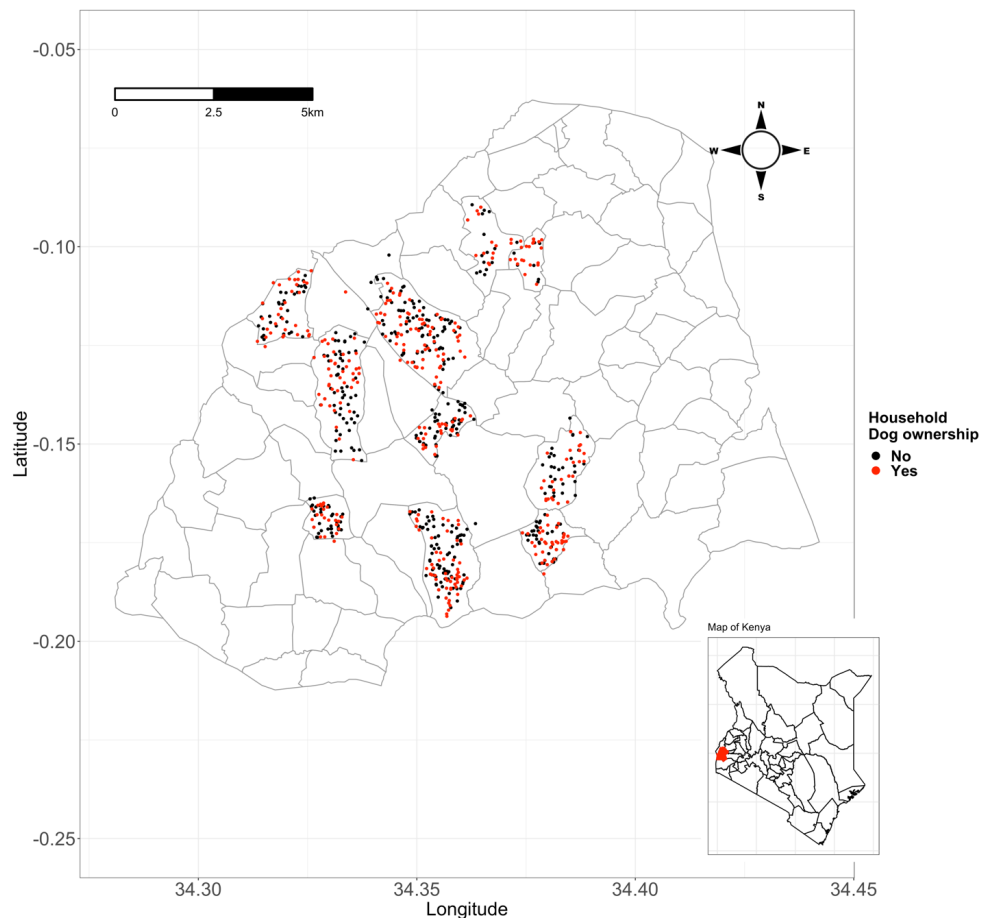
to bite patients, strengthening surveillance for rabies in humans and animals, and public awareness and education<sup>8</sup>. Studies on dog health and demographics can be informative in providing data for effective planning of dog vaccination campaigns that achieve and maintain sufficient herd immunity for rabies elimination.

Here we describe the design of a dog health and demographic study (dog-HDSS) within an existing human health and demographic surveillance study. Using baseline data from the dog cohort study, we quantify demographic parameters and local dog management practices relevant for rabies transmission.

## Methods

### Study area

The dog-HDSS is set in western Kenya within a linked human health and animal health syndromic surveillance study following > 1500 households in 10 villages regularly collecting health and socio-economic data from people and their animals<sup>10</sup>. The linked human-animal health syndromic surveillance study is itself conducted within a Health Demographics and Surveillance system (HDSS) run by Kenya Medical Research Institute (KEMRI)<sup>11</sup>. The HDSS covers 385 villages that lie to the North-East of Lake Victoria covering Alego-Usonga, Rarieda and Gem sub-counties in Siaya County. [Figure 1](#) is a map of the



**Figure 1.** A map of Asembo showing the study villages and distribution of households with dogs and those without dogs.

study area showing the study villages and distribution of dog owning and non-dog owning households.

### Dog health and demographic surveillance study design

All households participating in the linked human and animal syndromic surveillance, whether owning dogs or not, were eligible for inclusion into the dog cohort study. Each of the 1500 households is visited at least monthly by a community interviewer that collects information on the health of household members, and that of cattle, sheep, goats and chicken. Households consenting to enroll in the dog-HDSS had their dogs individually enrolled in the study. To allow for each dog to be followed longitudinally, each study dog received a unique identification number. To identify the study dogs, a combination of the dog names as given by the dog owner, sex, age, and coat color were used during the follow-up visits. At recruitment, a questionnaire collecting information on household demographics, dog age and sex, dog management practices, reproductive indices, vaccination status, dog health and dog bite information was administered. New dogs born or brought into the population during the study are recruited into the dog-HDSS during monthly household visits by the community interviewer.

During monthly visits to households, characteristics of each household are monitored such as human-mediated dog movement, any new births or deaths of dogs since the last visit and dog bites that have occurred in the household. Individual data on each dog in the study is also monitored including reproductive and vaccination status that may have changed since the last visit.

In addition to the regular household visits, the participating households have access to a toll-free number that they call to report cases of illnesses or death among their dogs. Following such reports, the veterinary team comprising of animal health assistants

and veterinarians responds to these cases within 24 hours by conducting detailed clinical examinations for sick dogs, postmortem examinations of dead dogs, collecting appropriate diagnostic samples and providing veterinary treatments for sick dogs. These clinical visits comprise the third visit type of the dog cohort study. Figure 2 provides a schematic summary of the dog-HDSS study design. Table 1 provides details of the dog information collected at each of the three visit types: recruitment, monthly follow-up visits, and clinical visits.

### Data collection

The three sets of questionnaires (recruitment questionnaire, follow-up questionnaire and a clinical response questionnaire) were programmed on a personal digital assistant (PDA) to allow for electronic data capture. Data was downloaded from PDAs into a database at the end of each working day and backed up on servers.

### Data analysis

Data was cleaned and analyzed using R statistical software (version 3.4.1). Number of households, dogs and ages were summarized as means (95%CI) and while dog sex, dog management practices, dog movement as proportions.

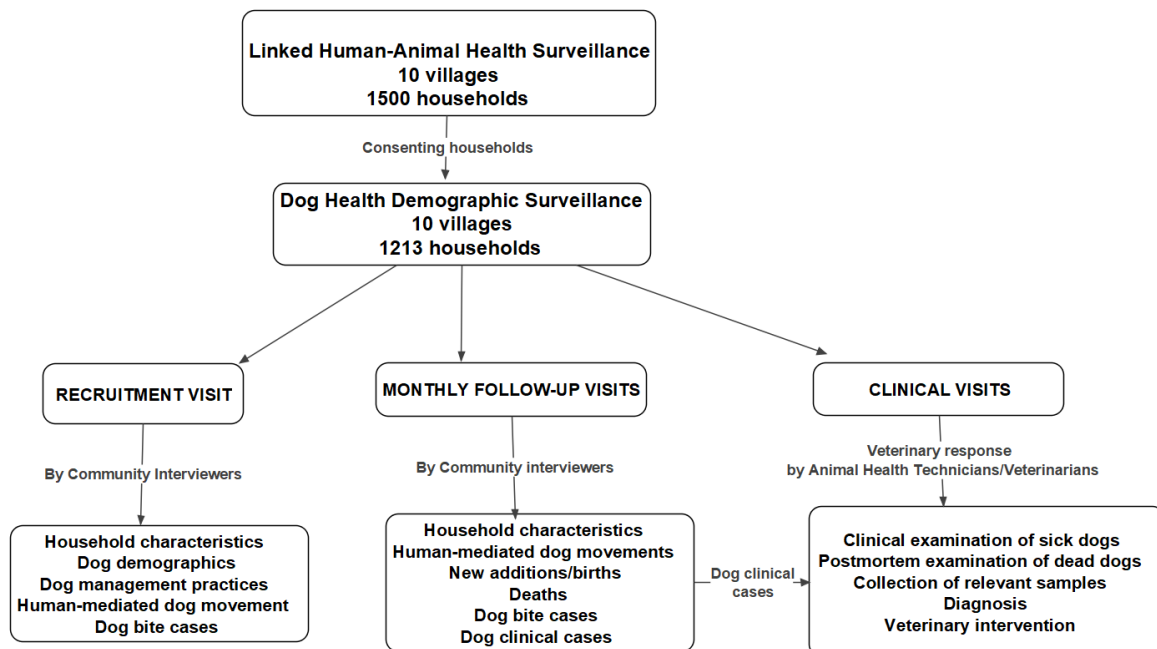
### Ethical clearance

The study received ethical approval from Kenya Medical Research Institute/Scientific and Ethics Review Unit (SERU) (Ref No. KEMRI/SERU/CGHR/046/3268). A written consent from dog owner's for participation in the study was obtained.

## Results

### Dog ownership and demography

A total of 1213 households consented to participate in the study and were recruited into the study between February and April 2017.



**Figure 2.** Schematic summary of the dog cohort study design.

**Table 1. A summary of demographic, ecological and health data collected in Western Kenya.**

Variable Type	List of variables	Visit type
<b>Household demographics</b>	Household size; members below 15 years of age; dog ownership status and reasons for dog owning or not	Recruitment
<b>Dog demographics</b>	Numbers of owned dogs; age and sex of each dog; breed; acquisition and geographical origin; dogs lost/sold/killed/died/given away	Recruitment & Monthly
<b>Dog management practices</b>	Handling; nature of movements (restricted/free roaming); feeding; waste disposal and breeding control (castration and spaying)	Recruitment & Monthly
<b>Reproductive indices</b>	Whelpings; litter size; puppy survival; fate of puppies (given away, killed, died, sold or present)	Monthly
<b>Vaccination status</b>	Vaccination against Rabies, Parvo virus, Leptospirosis, Canine Distemper, Hepatitis and para-influenza	Recruitment & monthly
<b>Health (sickness and death)</b>	Recorded syndromes: gastrointestinal, respiratory, neurologic, skin, musculoskeletal, urogenital, vision and hearing problems	Recruitment & monthly
	Clinical samples collected: whole blood, serum, fecal swabs, vaginal swabs, prepuce swabs and brain samples from rabid suspect dogs.	Clinical
<b>Dog bite data</b>	Dog bite reports, history of biting dogs and access to post-exposure prophylaxis	Recruitment, monthly

The study households had a median and mean of 5 household members (range 1 – 18). From the households recruited, 460 (38%) owned dogs. For the households without dogs at the time of setting up the study, 526 (70%) reported owning dogs previously. The reasons reported for the loss of their dogs included death due to disease (63%), disappearance (11%) or being killed (19%). The remaining proportion (7%) could not recall what happened to their dogs. For the households that had never owned dogs previously, 44% reported disliking dogs, 23% reported that dogs were expensive to maintain, while the rest did not provide any specific reason. Table 2 provides a summary of dog ownership and management practices.

In total, 802 dogs were recruited into the study. More than half (52%) of the recruited dogs with known ages were  $\leq 1$  year. Dog owners did not know the age of 16% of the dogs recruited. The female dog: male dog ratio was 1:1.3. Using the number of household members and number of dogs in the study, we estimated the dog: human ratio at 1:7. The dog density for Siaya County was estimated at 54 dog/km<sup>2</sup> (range 50–57 dog/km<sup>2</sup>) using the dog to human ratio and average number of dogs per household. The predominant breed of dogs (99% of the dogs) kept was the local breed. Nearly all households (97%) reported keeping dogs primarily for security reasons, with only a few households' keepings dogs as pets or for hunting.

#### Sources of dogs

Most dogs in surveyed households were acquired as gifts (71%) when they were puppies while 21% were born from dogs already owned by the household. The remaining 8% were either bought from elsewhere or owners could not clearly recall their origin. Most of the dogs not born within households were acquired within a radius distance of 5 km (87%); 97% of the

dogs were from within a 10km radius, and only 3% of dogs were obtained from beyond a 10km radius.

#### Dog handling management practices

The majority (35%) of the study dogs were mainly taken care of by women, 31% by men, and 11% by children; with 23% apparently cared for by any household member. Only 9% of the dogs were provided with kennels. Most dogs (97%) were fed on leftovers from family food waste and garbage pits. Scavenging for food from garbage dumping sites was common, with 27% of the respondents witnessing it with their own dogs, 44% with neighbors' dogs and 29% with unknown dogs.

The majority (61%) of the dogs were allowed to roam freely, 38% had their movement partially restricted while 1% of the dogs had their movement strictly confined within the household all the time. Partial restriction of movement was done mainly during the day only. Only 12 (3%) of the surveyed households had secure fences around their homesteads that could restrict dog movement, whereas 55% and 42% had no fence at all or a partial fence, respectively.

#### Rabies vaccination and population control

Only 37 (5%) of the study dogs had been vaccinated against rabies at the time of recruitment into the study. Breeding control practices were rare with only 48 (12%) of the 395 male dogs and 13 (5%) of the 291 bitches castrated and spayed, respectively.

#### Reproduction indices

At recruitment, we obtained information on the one-year reproductive history of female dogs recruited into the study. Out of the 201 female dogs above 8 months at recruitment, 92 (46%)

**Table 2. Dog ownership and management practices from the dog cohort.**

Parameter	Estimated value
Dog owning HH	460 (38%)
Non-dog owning HH	753 (62%)
Dogs/HH	0.7 (range: 0.6–0.7)
Dogs/Dog-owning HH	1.8 (range: 1.7–1.9)
Total number of dogs owned	802
Dog density	54 (range 50–57) dogs/km <sup>2</sup>
Average number of people/HH	5 (range: 1–18)
Male: female dogs	1.3:1
<b>Dog ages</b>	
Unknown	110 (16%)
Ages <1 year	360 (52%)
Ages >1 year	332 (48%)
Non-dog owning households that owned dogs previously (n= 526)	
<b>Reason for not owning dogs</b>	
<i>Died from disease</i>	63%
<i>Lost</i>	11%
<i>Killed</i>	19%
<i>Unknown</i>	7%
Non-dog owning households that have never owned dogs (n=227)	
<b>Reason for not owning dogs</b>	
<i>Don't like dogs</i>	44%
<i>Dogs are expensive to maintain</i>	23%
<i>No specific reason</i>	33%
<b>Dogs confined (n=733)</b>	
<b>Type of confinement</b>	
<i>No confinement (free roaming)</i>	61%
<i>Partial confinement (see time of confinement, below)</i>	38%
<i>Complete confinement</i>	1%
Partial confinement (n= 281)	
<b>Time of confinement</b>	
<i>Daytime only</i>	55%
<i>Occasionally</i>	44%
<i>Nighttime only</i>	1%

**HH, household.**

had whelped in the year preceding the recruitment visit. The mean whelping per year was 1.4 and the average litter size in the last whelping was 4.8 (range 1–12) puppies per bitch.

## Discussion

Here we present the design of a dog health and demographic surveillance study established within an existing human health and demographic surveillance study (HDSS), and using

baseline data from the dog-HDSS we quantify key demographic parameters and management practices that underlie rabies transmission in rural western Kenya.

Neglected zoonotic diseases such as rabies are responsible for a significant burden of infectious diseases in Africa and Asia. For most of these diseases, good epidemiological data are scant resulting in gross underestimation of disease burden and low



prioritization of their control<sup>12,13</sup>. The lack of reliable population-based health data has led to the establishment of HDSS across low and middle-income countries in Africa and Asia to collect longitudinal epidemiological data within defined populations<sup>14</sup>. These HDSS provide opportunities to not only understand disease in humans but can be extended to include health and demographic data on animals living in close proximity to humans in these HDSS populations.

The design of the dog-HDSS utilized the social units (households) established under the KEMRI HDSS in western Kenya. Working within the HDSS makes it easy to identify households to recruit and to conduct follow-up visits, taking advantage of existing community engagement on surveillance. The International Network for the Demographic Evaluation of Populations and their Health (INDEPTH) Network lists 36 HDSSs in Africa<sup>14</sup>. These provide opportunities to improve epidemiological data on linkages between human and animal health, and establish health and demographic surveillance systems for animals that collect vital events including births, deaths (by age and sex), illness, and causes of death<sup>10,15</sup>.

Reported dog demographics from this study show a dog population with high turnover (half the dog population is under 1 year old). High turnover rates result in rapid declines in herd immunity between vaccination intervals and is the reason for requiring high annual vaccination coverage reaching 70%, even though the basic reproductive number for rabies ( $R_0$ ) is consistently  $< 2$  across settings with varying dog population densities<sup>5</sup>. Interventions that reduce the rate of dog population turnover (reducing fecundity, improving life expectancy) could slow the decline in vaccination coverage between rabies campaigns and increase the probability of rabies elimination<sup>16</sup>.

Our study reports minimal dog population control (castration of male and neutering of female dogs). There is however little empirical evidence that such population control interventions play a significant role or are cost-effective in reducing dog rabies incidence and subsequent transmission to humans<sup>17</sup>. Indicators of responsible dog ownership in this population including sheltering dogs in kennels, provision of feed to dogs to reduce scavenging, and controlled dog movement to reduce roaming are poor, and similar to those reported elsewhere<sup>18,19</sup>. These characteristics facilitate disease spread and pose a public health challenge as free roaming dogs may increase the likelihood of dog bites to humans, and of accidents on the roads and the potential spread of diseases that are zoonotic<sup>19</sup>.

In the absence of rabies vaccination campaigns, our study reported only a small proportion (5%) of dogs had a history of rabies vaccination. A large population of unvaccinated dogs supports endemic circulation of rabies. Although the majority of the dogs are free roaming, they were owned and are likely to be available for vaccination when campaigns are organized. A review of publications on dog parenteral vaccinations in Africa has reported similar results on dog ownership and accessibility for

vaccination<sup>20</sup>. Importantly, the review reported significantly higher vaccination coverage under free-of-charge vaccination schemes compared to vaccination schemes where dog owners paid vaccination costs, indicating vaccination costs may be a more important determinant to vaccination coverage than accessibility of free roaming dogs.

Security was the main reason for dog keeping, and the male dominated sex ratio is in agreement with findings from other studies in Kenya and across the continent<sup>18,20,21</sup>. This may be attributed to several factors including the perception that male dogs make good hunters and guard dogs compared to female dogs, and the stress on female dogs associated with reproduction increasing their mortality rates.

Most of the demographic and ecological studies conducted in Africa are cross-sectional, making it difficult to estimate demographic parameters such as birth rates, death rates and causes of deaths which inform dog population turnover. Our dog-HDSS provides an ideal opportunity to determine health and demographic parameters of a dog population in a rural setting over time. Establishing survival and mortality rates and the associated risk factors related to rabies in such a setting will allow estimation of their impact on rabies control and elimination strategies. The demographic and ecological estimates from such studies are important in parameterizing models to estimate the rabies burden, and to examine rabies dynamics and test the impact of alternative intervention strategies on rabies spread and time to elimination<sup>1,5,22,23</sup>.

To meet the 2030 global target for the elimination of dog-mediated human rabies, epidemiological data on the population dynamics of dogs, incidence of rabies, and impact of rabies intervention strategies are urgently required. Embedding these kinds of studies on existing platforms such as HDSS across rabies endemic regions presents opportunities to improve data availability to answer policy questions and inform the design of effective and sustainable rabies control programs. Parameters such as dog to human ratios are critical to estimating dog population sizes, determining vaccine needs, and estimating post-vaccination coverage. Ultimately, reviewing progress and confirming elimination of human rabies requires surveillance systems that extend beyond health facilities to local communities. Integrated human and animal health and demographic surveillance systems are unexploited opportunities for addressing disease burden associated with rabies and other neglected zoonotic diseases.

## Data availability

### Underlying data

OSF: Dog Health and Demographic Surveillance Study (dog-HDSS) in Western Kenya, <https://doi.org/10.17605/OSF.IO/BZ78A><sup>24</sup>.

Data are available under the terms of the [Creative Commons Zero “No rights reserved” data waiver](#) (CC0 1.0 Public domain dedication).



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## References

- Hampson K, Coudeville L, Lembo T, *et al.*: **Estimating the global burden of endemic canine rabies.** *PLoS Negl Trop Dis.* 2015; 9(4): e0003709.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Lembo T, Hampson K, Kaare MT, *et al.*: **The feasibility of canine rabies elimination in Africa: Dispelling doubts with data.** *PLoS Negl Trop Dis.* 2010; 4(2): e626.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Morters MK, Restif O, Hampson K, *et al.*: **Evidence-based control of canine rabies: A critical review of population density reduction.** *J Anim Ecol.* 2013; 82(1): 6–14.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Cleaveland S, Lankester F, Townsend S, *et al.*: **Rabies control and elimination: a test case for One Health.** *Vet Rec.* 2014; 175(8): 188–93.  
[PubMed Abstract](#) | [Publisher Full Text](#)
- Hampson K, Dushoff J, Cleaveland S, *et al.*: **Transmission dynamics and prospects for the elimination of canine rabies.** *PLoS Biol.* 2009; 7(3): e53.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Coleman PG, Dye C: **Immunization coverage required to prevent outbreaks of dog rabies.** *Vaccine.* 1996; 14(3): 185–186.  
[PubMed Abstract](#) | [Publisher Full Text](#)
- Gsell AS, Knobel DL, Kazwala RR, *et al.*: **Domestic dog demographic structure and dynamics relevant to rabies control planning in urban areas in Africa: the case of Iringa, Tanzania.** *BMC Vet Res.* 2012; 8: 236.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Bitek A, Osoro E, Munyua P, *et al.*: **A hundred years of rabies in Kenya and the strategy for eliminating dog-mediated rabies by 2030 [version 1; referees: 3 approved, 1 approved with reservations].** *African Acad Sci Open Res.* 2018; 1: 23.  
[Publisher Full Text](#)
- Abela-Ridder B, Knopf L, Martin S, *et al.*: **2016: the beginning of the end of rabies?** *Lancet Glob Health.* World Health Organization; 2016; 4(11): e780–e781.  
[PubMed Abstract](#) | [Publisher Full Text](#)
- Thumbi SM, Njenga MK, Marsh TL, *et al.*: **Linking human health and livestock health: a “one-health” platform for integrated analysis of human health, livestock health, and economic welfare in livestock dependent communities.** *PLoS One.* 2015; 10(3): e0120761.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Odiambo FO, Laserson KF, Sewe M, *et al.*: **Profile: The KEMRI/CDC health and demographic surveillance system—Western Kenya.** *Int J Epidemiol.* 2012; 41(4): 977–987.  
[PubMed Abstract](#) | [Publisher Full Text](#)
- King CH, Bertino AM: **Asymmetries of poverty: Why global burden of disease valuations underestimate the burden of neglected tropical diseases.** *PLoS Negl Trop Dis.* 2008; 2(3): 977.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Welburn SC, Beange I, Ducrotoy MJ, *et al.*: **The neglected zoonoses—the case for integrated control and advocacy.** *Clin Microbiol Infect.* Elsevier Ltd; 2015; 21(5): 433–443.  
[PubMed Abstract](#) | [Publisher Full Text](#)
- Sankoh O, Byass P: **The INDEPTH Network: filling vital gaps in global epidemiology.** *Int J Epidemiol.* 2012; 41(3): 579–88.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Conan A, Akerele O, Simpson G, *et al.*: **Population Dynamics of Owned, Free-Roaming Dogs: Implications for Rabies Control.** *PLoS Negl Trop Dis.* 2015; 9(11): e0004177.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Cleaveland S, Thumbi SM, Sambo M, *et al.*: **Proof of concept of mass dog vaccination for the control and elimination of canine rabies.** *Rev Sci Tech Off Int Epiz.* 2018; 37.  
[Publisher Full Text](#)
- Taylor LH, Wallace RM, Balaram D, *et al.*: **The Role of Dog Population Management in Rabies Elimination—A Review of Current Approaches and Future Opportunities.** *Front Vet Sci.* 2017; 4: 109.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Kitala P, McDermott J, Kyule M, *et al.*: **Dog ecology and demography information to support the planning of rabies control in Machakos District, Kenya.** *Acta Trop.* 2001; 78(3): 217–230.  
[PubMed Abstract](#) | [Publisher Full Text](#)
- Schildecker S, Millien M, Blanton JD, *et al.*: **Dog Ecology and Barriers to Canine Rabies Control in the Republic of Haiti, 2014–2015.** *Transbound Emerg Dis.* 2017; 64(5): 1433–1442.  
[PubMed Abstract](#) | [Publisher Full Text](#)
- Jibat T, Hogeveen H, Mourits MC: **Review on Dog Rabies Vaccination Coverage in Africa: A Question of Dog Accessibility or Cost Recovery?** *PLoS Negl Trop Dis.* 2015; 9(2): e0003447.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Jamleck M, Andrew T, Susan M, *et al.*: **Dog Populations and Dog-Keeping Practices in Relation To Rabies Control in Kisumu and Siaya Counties, Kenya.** *Int J Agric Sci Vet Med.* 2016; 4: 3.  
[Reference Source](#)
- Zinsstag J, Dürr S, Penny MA, *et al.*: **Transmission dynamics and economics of rabies control in dogs and humans in an African city.** *Proc Natl Acad Sci U S A.* 2009; 106(35): 14996–15001.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Ferguson EA, Hampson K, Cleaveland S, *et al.*: **Heterogeneity in the spread and control of infectious disease: consequences for the elimination of canine rabies.** *Sci Rep.* Nature Publishing Group; 2015; 5: 18232.  
[PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Mwangi T: **Dog Health and Demographic Surveillance Study (dog-HDSS) in Western Kenya.** *OSF* 2018.  
<http://www.doi.org/10.17605/OSF.IO/BZ78A>

# Open Peer Review

Current Peer Review Status:



Version 1

Reviewer Report 29 May 2019

<https://doi.org/10.21956/aasopenres.13971.r26929>

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**Moustafa Kardjadj** 

Laboratoire de Recherche "Santé et Productions Animales", Ecole Nationale Supérieure Vétérinaire (ENSV) d'Alger, Algiers, Algeria

Generally, the manuscript contributes to our knowledge of demography and management practices of domestic dog in western Kenya. The manuscript documents for the first time the demography of domestic dog population in Kenya in particular using baseline data from a dog cohort study and establishing survival and mortality rates. The manuscript is well written and can be considered for indexing after some revisions.

**The title** seems long and does not represent the aim of the study.

## The aim of the study:

I think that you need to state that you used the cohort study to follow longitudinally dogs from households from rural area to estimate demography and management practices of domestic dog in western Kenya.

## Methods:

- How many households were investigated in the study, is it 1500 (as mentioned in Figure 2) or more (as mentioned in the first paragraph)? Please be precise.
- By what method was the age was determined? (Is it by dentition – because it is not reliable).
- Is there a vaccination certificate to be examined by the investigator? By what means was rabies vaccination verified? The same question could be asked regarding breeding control verification.
- What about the duties of the investigated dogs - were the dogs investigated used for hunting, herding, guarding purposes or were they only pets - this information could be valuable when linked with the dogs confinement practice.

## Results:

- Please state the reason for not consensus of the **287** households (1500 -1213) to participate in the study.
- Please be precise, is the mean equal to the median = 5? (If it is the case, please provide the mode).
- Was the dog density estimated in the ten villages or in Siaya County? Please explain. Also please add Siaya County to Figure 1.

- Some information was stated as collected in the Methods section (Figure 2) but not reported in the Results such as the response % from households during the first visit, the number of visits performed, the history of dog bite reports and clinical case reports, also the postmortem diagnostic report.

**Discussion:**

- Please discuss your demographic results with the neighboring countries.
- Please state the rabies epidemiological situation in these areas and discuss the rabies vaccination coverage.
- Please discuss properly the reasons for high turnover rates such as death and dog movement.

**Is the work clearly and accurately presented and does it cite the current literature?**

Yes

**Is the study design appropriate and is the work technically sound?**

Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**

Partly

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Partly

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Epidemiology of TADs and zoonosis.

**I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.**

Reviewer Report 23 May 2019

<https://doi.org/10.21956/aasopenres.13971.r26938>

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**Nozyechi Ngulube Chidumayo**

Clinical Studies Department, School of Veterinary Medicine, University of Zambia, Lusaka, Zambia

The reviewed paper "Dog health and demographic surveillance survey in Western Kenya: Demography and management practices relevant for rabies transmission and control" is well-written and the study provides valuable information necessary for planning and implementing rabies control programs. My major comment is that there is a lot of data in the materials and methods that have not been included in the results.

### **Comments:**

#### **Abstract:**

- Please provide information on the study duration/recruitment period in the abstract.
- According to the materials and methods, the dog demographic data were collected on a monthly basis but the paper only reports on recruitment data.

#### **Materials and methods:**

- Please provide information on the study duration/recruitment period. The materials and methods state that the data was collected at recruitment and monthly, but the results only report on data collected at recruitment. This is confusing, because after reading the materials and methods, one expects to see monthly follow-up and clinical visits results. If the results from monthly follow-up and clinical visits are not part of this paper, this should be explained clearly in the materials and methods.

#### **Data analysis:**

- Was the data tested for normality? The data on the number of households, dogs, and ages were summarised as mean and 95% confidence intervals but the datasets are not normally distributed based on the Shapiro-Wilk test. If the data is not normally distributed, it should be reported as median, interquartile range and range.

#### **Results:**

- Dog/household data are reported as mean but the dataset is not normally distributed and should be reported as median, interquartile range, and range.
- Age results should be expanded to include the median and range for the total population, males and females. In addition, it would be useful to include the proportion of dogs less than 3 months since these dogs are usually excluded from vaccination and a high proportion of this age group can reduce the vaccination coverage.
- Is the dog demography similar for all the sub-counties? Could the authors please report both the overall and sub-country results?
- Data dog bite reports and history of biting dogs that were collected at recruitment have been omitted from the results.
- Health data were collected at recruitment but not reported in the results.

#### **Discussion:**

- Page 7 paragraph 3. Please provide an outline of the factors that affect dog turnover rates before listing the interventions.

**Is the work clearly and accurately presented and does it cite the current literature?**

Yes

**Is the study design appropriate and is the work technically sound?**

Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**

Partly

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Epidemiology, meta-analysis, disease modelling


**I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.**

Reviewer Report 17 May 2019

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**Folorunso O. Fasina** 

Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

The manuscript presents the research from a One Health point of view. Such a presentation is very good and emphasizes the need to look beyond the silo-approach to research to effectively utilizing the same facility to achieve multiple objectives.

The manuscript was well written and has possibly benefitted from the input of the previous reviewer but certain issues remain unsolved which will add value to the document. These include:

1. Page 3 of 11, Introduction, Line 2: "...and among rural populations." It should read, "...and among peri-urban and rural populations". It should be understood that rabies is a challenge in both peri-urban and rural populations equally and only the affluent urban population can claim some degree of freedom.

2. Page 3 of 11, Methods, Line 3: Is it >1500 or exactly 1500 households? All other references were made to 1500 and not >1500.
3. Page 4, Result, Dog Ownership and demography, Line 1: Should read, "A total of 1213 (81%)..."
4. Page 5 of 11, line 1 & 2 below Table 1: "...median and mean of..." - Why not stick to one, median or mean in this case while the full details remain in Table 2? If you must use both in the text, differentiate the results, you cannot say that "median and mean of 5 household members (range 1-18)". The median can have such range based on the minimum and maximum values. The mean will usually be with a 95% confidence limit and I doubt if it will be this wide. Check again.
5. Page 5 of 11, line 8 & 9 below Table 1: For households that had never owned dogs previously... (cite the number to follow) e.g. (n = ??).
6. Page 7 of 11. Discussion, between paragraph 2 and 3: It is important to mention the mean human/dog ratio for households in this paper due to its OH focus. Understand that this paper leveraged on the existing HDSS for human - there is, therefore, no way this information will not be available for analysis. The dynamics of human-animal interactions can also be expatiated upon, as well as how these mixed human-dog populations influence disease dynamics.
7. Page 7 of 11. Discussion, paragraph 4, line 8-11: The authors mentioned about the interventions that reduce the rate of dog population turnover, it will be apt if those interventions are listed first here before going into their details in the succeeding paragraphs.

## References

1. Kwoba E, Kitala P, Ochieng L, Otiang E, Ndung'u R, Wambura G, Hampson K, Thumbi S: Dog health and demographic surveillance survey in Western Kenya: Demography and management practices relevant for rabies transmission and control. *AAS Open Research*. 2019; **2**. [Publisher Full Text](#)

**Is the work clearly and accurately presented and does it cite the current literature?**

Yes

**Is the study design appropriate and is the work technically sound?**

Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**

Partly

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Partly

**Competing Interests:** No competing interests were disclosed.



**Reviewer Expertise:** Viral epidemiology, disease modeling and animal health economics.

**I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.**

Reviewer Report 17 April 2019

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**Anne Conan**

Department of Biomedical Sciences, Ross University School of Veterinary Medicine, Basseterre, Saint Kitts and Nevis

The reviewed paper “Dog Health and demographic surveillance survey in Western Kenya” is well written and gives some important baseline data which can be used for the future. However, from my point of view there is one major issue in the paper that should be addressed: the purpose of the paper. Following the objective and the material and methods, this is a study design paper. Unfortunately the title of the paper doesn’t translate this objective. Moreover, as a method paper, more results should be given about the implementation of the survey: how many teams? What was the response rate (after the 1<sup>st</sup> visit)? Any data on the number of calls from people after 6 months, for example. Figures should be related to the results and not the method. The questionnaires should be added as supplementary information.

#### Minor comments:

##### Abstract:

- Number of dogs/Household, mean=2: is this not the median?

##### Methods:

- The number of households investigated should be clearer: first >1500, then 1500 in Figure 2. Give an exact number.
- How is the age determined? Indicate in the method and not in results.
- Give reference for R software.
- The data analyses part is not clear. Please reformulate.
- All questions of the recruitment visit don’t give a timeline: for example “dog bite cases”: is it asked during the last year, the last 5 years, or ever? Same for vaccination.
- What about the movement not mediated by humans?

##### Results:

- Is the dog-HDSS still running? Can you give the responding % for 2017, and number of clinical cases, without giving full data analyses?
- A lot of the text repeats the information from the table, and should be cut.
- What is the local breed?

- “The dog density for Siaya County”: where is it?
- Do you have information on the cat populations?
- Rabies vaccination: what was the question? Change if vaccinated in the last year, 3 years or ever.

Discussion:

- “The lack of reliable population-based health data led to the establishment of *human* HDSS...”.
- The 2<sup>nd</sup> paragraph should be later.
- High turnover is not only due to reproduction only, but also to death and moving out. Half of the population can be less than 1 year at a certain point without high turnover, if all puppies die for example, the population of adults is then stable.
- Include the vaccination coverage in the discussion.
- “In the absence of rabies vaccination...” : I haven’t seen these results. Please include in the results.
- “A review of publications...”: not clear from where - the author?
- End of the same paragraph “...than accessibility of free roaming dogs”: give reference.

Figure 1: Several maps should be done as this is a method paper:

1. Where are the HDSS villages/dog-HDSS villages?
2. Owning household/non-owning household. Change colours to allow a reading of legend in black and white. Give the boundary villages, what are the other boundaries?

Figure 2:

- What is the “dog clinical cases”? It is not described in the methods.

Table 2:

- Please indicate absolute frequency.
- Dog/dog-owning households: how can the range have a decimal? Same for dogs/HH.
- Indicate in the title: “during the first recruitment”.
- Change the format for “Reason for not owning dogs”; this is not clear between previous owner and not previous owner.

**Is the work clearly and accurately presented and does it cite the current literature?**

Yes

**Is the study design appropriate and is the work technically sound?**

Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**

Yes

**If applicable, is the statistical analysis and its interpretation appropriate?**

Yes

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Partly

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Rabies, dog population, epidemiology of veterinary infectious disease in low-income areas

**I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.**

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